A Data-Driven AI Framework to Improve Urban Mobility and Traffic Congestion in Smart Cities

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November 2018

Abstract: One of the most talked-about problems at the start of the twenty-first century is effective transportation, which is one of the numerous challenges the globe is experiencing. Technology is playing a critical role in helping to tackle the current transportation problems as smart cities evolve. Smart cities feature the modernized form of civilization worldwide as they leverage increasing technological advancement, including Artificial Intelligence, in running city initiatives alongside addressing urban challenges. Traffic forms a major challenge in urban development due to various factors, such as poor planning. The innovative approaches, exemplified by integrating shop and delivery options in smart cities, will alleviate traffic congestion challenges. This research study pinpoints the Actor-Network Theory (ANT) principles and pragmatism as the guiding approaches in the research and enhancing the integration. The data collection methods included in the research included interviews, reports, and media content essential for understanding the complex interrelations of smart city initiatives. As depicted in the data analysis, the ANT and pragmatic framework form the foundation of shaping the future urban landscapes.

Keywords: Artificial Intelligence (AI), Actor-Network Theory (ANT), pragmatism, smart city, traffic congestion, shop

Introduction

The goal of the smart city project is to combat global warming and offer a practical and affordable way of life for everyone (Gössling, 2016, Sharma, 2017). It is obvious that the global warming process needs to be slowed down and, if at all possible, stabilized. The use of these resources is the primary contributor to global warming, hence there should be a significant decrease in all forms of carbon use. Between 1971 and 2001, the total amount of CO2 emitted globally rose by roughly 60%, reaching around 24 billion tonnes (Banister, 2005).

The urban city and civilization have resulted in the emergence of the smart city concepts as depicted worldwide. Alongside the world revolutions to the emergence of increased cities and technological advancement, various challenges emerge, exemplified by the increased traffic congestion alongside modernized developments. As witnessed in various cities, traffic congestion. Alongside the increasing traffic congestion, it not only deteriorates the urban movement but also exacerbates environmental pollution using fossil fuels (Sofronijevic et al., 2014). An extensive analysis of the smart city initiatives incorporates the shops and delivery propositions integrated with artificial intelligence (AI), hence fundamental in revolutionizing urban mobility. Exploring the intricate interrelation between the human and non-human actors within the urban setting unravels the various possibilities for creating efficient and sustainable urban development.

Research Questions

Based on the various challenges emerging in the increasing smart cities and traffic congestions alongside the delivery propositions, this research objectives include the following;

RQ1: What are the effective models for integrating shop and delivery propositions into smart city approaches through AI?

RQ2: What are the current and fundamental network approach and inter-relation essential to spearhead the integration?

RQ3: What are the likely effects of implementing the framework within the urban traffic movement and associated congestion?

Literature Review

Modern welfare and civilization have factored in the increasing change in the urban planning paradigm as it calls for improved planning alongside environmental conservation concerns. The new approach to urbanization and development incorporates extensive technological utilization alongside the data-driven economy emphasizing urban development (Tomson, 2017; Wei et al., 2016). As technological development takes center stage in urbanization, urban planning emphasizes creating an efficient, sustainable, and accommodative environment for urban beings to thrive in. This modernized approach incorporates integrating digital technologies to run the cities alongside the augmentation of the various urban policies. The new modernized policies running the smart cities differ from the traditional model as the new incorporates technological sensitivity alongside climate change and consideration of sophisticated human welfare (Caragliu et al., 2011). In smart cities, for instance, the new urban policies have centered on reducing carbon and fossil fuel emissions by increasing the taxation on fossil automotive and consequently lowering the electric and environment-friendly engines alongside renewable energy sources. These measures seek to reduce the number of personal vehicles using fossil fuels, especially personal vehicles (Smith et al., 2020). However, despite these efforts, traffic congestion continues to build up across smart cities, jeopardizing the efforts previously exerted and leading to productivity losses and negative environmental effects on society.

Various research studies have explored the possibility of integrating artificial intelligence (AI) in urban city development and revolutions, especially in addressing the challenges of increasing urbanization. For instance, major studies have addressed traffic congestion by incorporating artificial intelligence (Chan, 2015). Some of the pilot studies undertaken in different smart cities developed in various parts of the world have depicted the effectiveness of artificial intelligence in optimizing transportation networks and enhancing the smooth traffic flow across the cities. In essence, the cities that have integrated artificial intelligence into the transportation networks have realized a reduced travel time, hence the increased maneuver over the city (see Figure 1).

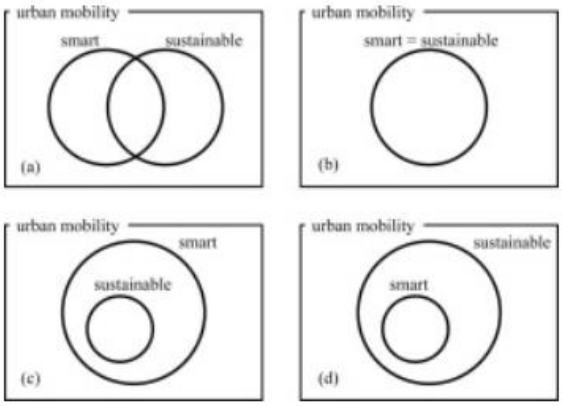

Figure 1. Venn Diagrams of Urban Mobility. *Adapted from* (Banister, 2005)

The integration of artificial intelligence in transportation networks incorporates real-time data utilization as leveraged from various sources, hence the ease of access to real-time traffic development. This approach includes incorporating sensors, GPS services and devices, and traffic cameras, enhancing adaptive urban movement and development solutions (Chan,

2015). The AI integration, especially within the urban movement management, aligns with the increasing mobilization to achieve the smart city initiative goals and ambitions. Hence, this approach correlates to the increasing development of big data in making informed choices in modern mobility development.

Amidst technological advancement, the Actor-Network Theory (ANT) and pragmatism have emerged as the upcoming technologies in the context of artificial intelligence integration in traffic congestion management. The two aspects have demonstrated their ability to understand the complex interrelation between human and non-human actors within urban development. As depicted in some research studies, human and non-human actors have an essential role in influencing socio-technical networks, especially within the context of technological development worldwide (Poletti & Michieli, 2018). This approach incorporates the relational urban systems alongside the emphasis on the inter-correlation across the various elements incorporated in urban development. The theoretical framework has further emphasized the performative nature, especially in the context of smart city initiatives (Tompson, 2017).

The pragmatism approach provides an exploratory avenue in comprehending the development of smart city initiatives. This approach has emphasized effectiveness as it boasts of the profound origin in the American pragmatist philosophy. According to its postulation, knowledge and action are intertwined with considering the situation and the contingent practice planning nature (Fletcher et al., 2017). The approach incorporated in artificial intelligence will demand immediate urban intervention consideration as it appreciates the diverse nature of solving the vast smart city development challenges.

Theoretical Framework

Actor-network theory (ANT), since its invention in 1986, features the diverse nature of the intricate interrelation between human and non-human actors alongside the extensive utilization of technological systems. ANT posits that human and non-human integration is fundamental in shaping the functional nature of socio-technical networks (Born & Barry, 2018). As formulated within this context, ANT entails unpacking the diverse actors incorporated within the smart city initiatives, such as featuring urban planning and advanced AI algorithms alongside the invention of drones for delivery (Berger et al., 2014). The extensive approach enhances the examination of the actors in the broad context of forming alliances, negotiating interests, and collectively influencing the urban movement, reducing traffic congestion (see Figure 2).

Rorty coined pragmatism to complement the ART by profounding the action and context in influencing the development and the urban initiatives execution. The paradigm examines the effectiveness and correlation of the initiative as fundamental in the situation context and action. The smart city initiative incorporates pragmatism in exploring the initiative unfolding within only an urban environment, constituting the situation environment and aspiration in its transformation (Born & Barry, 2018). This approach is, hence, fundamental in analyzing the practical implications and outcomes within the integration of the shop and the delivery proposition in the emphasis on the adaptive and contextualized-sensitive approaches.

Smart city ideas may be sparked by artificial intelligence. Artificial intelligence (AI) can process enormous volumes of data from several sources, enabling the discovery of insights that can be used to improve the efficacy and efficiency of municipal operations while lowering related costs. AI-powered smart city solutions have the ability to learn from how residents interact with their neighborhoods. It is reasonable to believe that AI algorithm quality will improve every day. AI has the ability to research urban residents' behaviours and improve urban

administration and planning. It might make previously unknown facts public, enabling the local government to better foresee inhabitants' demands and cater to them beforehand.

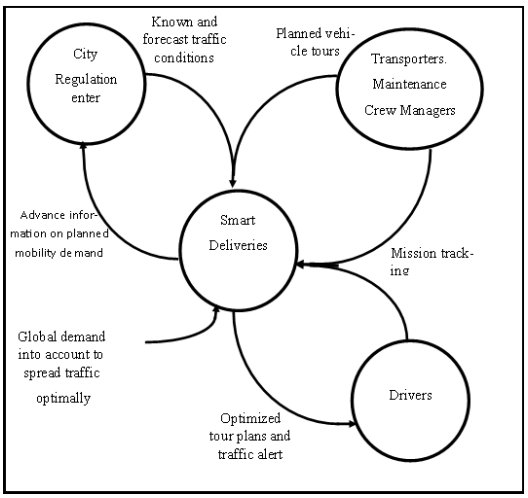

Figure 2. Smart deliveries architecture

Methodology

Theoretical Framework: This research adopted a mixed approach, qualitative and quantitative techniques. Actor-network theory (ANT) and pragmatism formed the basis for integrating the theoretical framework development. ANT provided the ultimate identification and analysis for the actor networks against pragmatism, which informed the contextual development of the smart city initiatives.

Data Collection: Modern-day applications and decisions are primarily real-time data driven approaches (Dash & Agarwal, 2016). The research entailed data collection from various sources, as exemplified by the interviews, reports, and media content. The semi-structured interviews featured the questionnaire undertaken with the various stakeholders in the initiatives as exemplified by the city planners, technology experts, and the residents. Furthermore, the reports and media content on smart city initiatives and urban mobility patterns provided a comprehensive overview of the actor networks. The research recruited 306 research participants, with whom only 200 accepted the interview as some withdrew from the research study mid-way, hence the withdrawal as research participants. In addition, the study utilized 50 research reports and ten media content drawn from the various media houses with consent from the media house managers.

Data Processing and Analysis: The research incorporated the coding of the interview transcription through the thematic analysis to facilitate the identification of the key actor-networks alongside their interactions. The application of content analysis helped extract information about smart city initiatives and urban mobility from the reports and media content.

Results and Discussion

Integration of the key stakeholders in AI, Shop, and Delivery proposition: The study findings illuminated the multifaceted actor networks as they intricately involved the smart city initiatives orchestration with emphasis on enhanced urban development. City planners, technology developers, local businesses, and residents' engagement formed the major actors within the smart city initiatives (Yuen et al., 2017). These key stakeholders are fundamental in enhancing the urban landscape development as responsive, efficient, and sustainable. Integrating the shop and delivery options alongside the technology improvisation forms the

foundational approach towards alleviating traffic congestion and elevating modern mobility within smart cities.

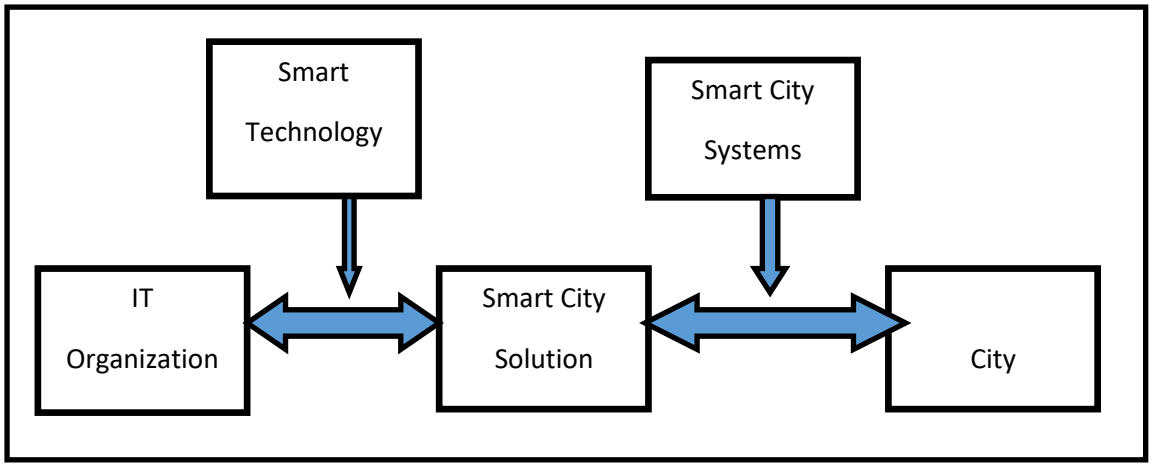

Figure 3. Technology and primary stakeholders in a smart city.

Key considerations in smart city development: The data insights from the research study indicated the emphasis on the various key considerations alongside the implication of the proposed framework, such as the imperative and contextually sensitive approaches in the context of smart city initiatives. According to this proposition finding, the urban environment comprises various heterogeneous social, cultural, and economic factors that require a multifaceted approach, unlike a single-modeled approach (Olofsson et al., 2016). The solution to address traffic congestion within smart cities should aim to mitigate specific needs, challenges, and opportunities according to each city context. The localized approach assures extensive effectiveness and fosters ownership and participation among the local stakeholders.

Artificial Intelligence in Easing Traffic Congestion: Technology features the ultimate technology in influencing the success of the initiatives improvised in the smart city initiatives. The technological approach incorporates the integration of AI-embedded technologies whose amplification facilitates data collection and analysis, hence fundamental in depicting real-time decision-making alongside adaptive interventions (Zio, 2016). The technological features through the various AI tools will enhance traffic management and optimize mobility within the city centers (Berger et al., 2014). Besides, feeding AI algorithms with various data from diverse sources is fundamental and dynamic in adjusting the traffic flow, reducing congestion, and enhancing urban mobility (see Figure 4). AI role in smart traffic mobility are below:

- The citizen-centered program can benefit from AI.
- The general public is welcome to offer suggestions using AI.
- AI has the capacity to use present resources in smart cities well

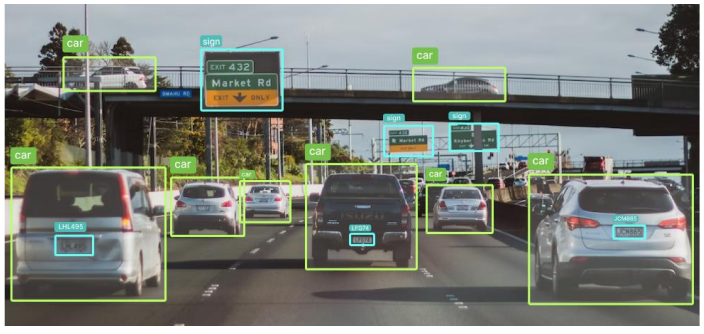

Figure 4. Application of AI (Computer Vision) in Traffic Control

Ethical issues on artificial intelligence in shop and deliver propositions alongside the increased mobility: The integration of the shop and the AI technologies alongside the aspirations in managing traffic congestion in smart cities carries various ethical aspects that demand the ultimate consideration (see Figure 5). For instance, regardless of the application region, technology plays a central role in urban governance, hence the rising concerns over data privacy, transparency, and inclusivity (Sholla et al., 2017). Data protection and security are fundamental demands of the various technological advancements essential for preventing urban disparities within the modern urban context (Dash & Agarwal, 2016). Every smart city development and the promoters of this development like Uber, Lyft, DoorDash etc. should incorporate inclusivity to access the benefits to all, guiding the development and deployment (Dash, 2017).

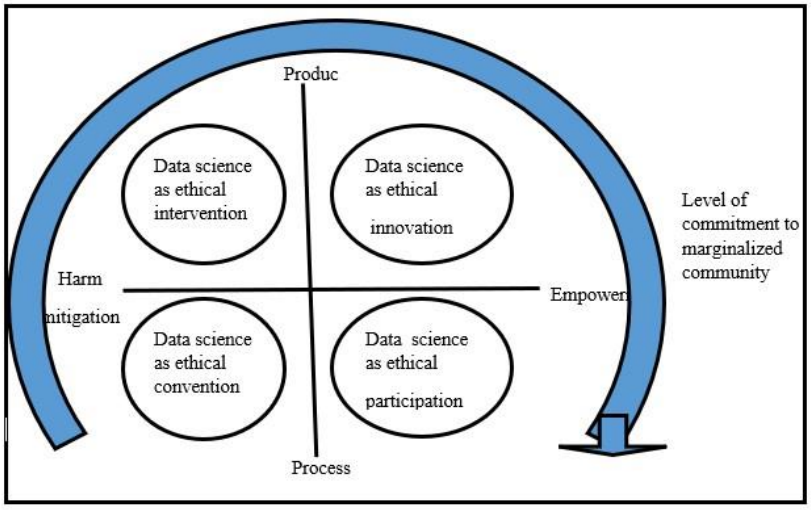

Figure 5. Ethical approaches in data science

ANT forms the interconnection between the various technological systems: ANT incorporates individuals, technologies, and institutions in shaping technological system development. All the factors influence urban mobility and smart city initiatives; hence, an integrated approach helps shape the interconnection between smart cities and technological advancement alongside link shop and deliver propositions (Zio, 2016; Black, 2018). The pragmatism approach complements the action and context within urban planning and smart city initiatives (Saggi & Jain, 2018). This approach enhances the contextualized approach in solving problems alongside recognition of the diverse and dynamic urban environment. Besides, integrating the shop and deliver proposition forms the foundation of the framework for addressing traffic congestion alongside leveraging technology for efficient transportation and delivery models (Born & Barry, 2018). The approach enhances the utilization of real-time data, AI algorithms, and adaptive models in optimizing urban mobility.

Conclusion

Ultimately, integrating the shop and deliver proposition cofound the future initiatives to embrace in the Smart city development initiatives driven by the incorporation of Artificial Intelligence technologies. The integration will fundamentally help revolutionize urban mobility, addressing the challenges of increasing urbanization, such as traffic congestion. The study finding illustrates the intricate network actors possible to incorporate in the institution of the particular intervention alongside the possible intervention areas. Incorporating a local and contextualized approach is essential for ethical considerations as the initiatives potentially help shape a responsive, efficient, and inclusive urban smart city development.

However, This research incorporates various limitations contravening the data utilization. For instance, the study relied on interviews and quantitative approaches, which are subject to alteration depending on the particular individuals enrolled in the study who may consider providing data subject to biases. The research did not extensively unravel the ethical considerations and implications of AI integration, data privacy, and inclusivity, leaving some research gaps.

The research study did not extensively incorporate the cultural and social dimensions, especially in influencing the adoption and success of smart city initiatives. This aspect leaves a research gap into which future research gaps can delve, especially in the context of the cultural factors influencing the acceptance and implementation of AI-driven solutions. The research further focused on the various immediately realizable benefits of the integration of the shop. It delivered a proposition with AI on which future research studies can explore the long-term sustainability of the various initiatives exemplified by scalability and consideration of the resource allocation and environmental effects. In addition, the research study did not consider comparing the proposed framework against the other alternative approaches, justifying the advantages and disadvantages against the other measures.

Acknowledgements

We gratefully acknowledge the two anonymous reviewers of this manuscript for their insightful and detailed comments, which helped us refine the article's final draft. This article is in honor of KIIT University's Ass. Professor Dr. Swayamsidha, for his impact, motivation, and time to review this final draft.

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